YTH TRANSLATION
JP (A) H10-139465

Applied: November 14, 1996
Application No.: JP H8-302982
Laid-Open: May 26, 1998

TITLE: **PRODUCTION OF RAW MATERIAL FOR OPTICAL ELEMENT FORMING**

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APPLICANT: Canon Inc. in the pores

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1. TITLE OF INVENTION

Production of raw material for optical element forming

2. ABSTRACT

[Purpose]
The purpose of this invention is to offer the easy and sure manufacturing method of glass gob which is suitable for the optical element forming material without a pit at the bottom surface.

[Methods to Solve Problems]
A manufacturing method of an optical element forming material which forms a glass gob used as an optical element forming material by receiving the molten glass flown from a pouring nozzle to a porous receiving mold, wherein the liquid is supplied to the said receiving mold to impregnate the pores, then the said molten glass is supplied to the said receiving mold so that the heat radiated from the molten glass vaporizes the liquid impregnated in the pores, and the pressure of this vaporized gas keeps the said molten glass supplied on the said receiving mold in the floating condition so that the glass gob with a desired surface condition can be formed.

3. PATENT CLAIMS

[Claim 1]
A manufacturing method of an optical element forming material which forms a glass gob used as an optical element forming material by receiving the molten glass flown from a pouring nozzle to a porous receiving mold, wherein the liquid is supplied to the said receiving mold to impregnate the pores, then the said molten glass is supplied to the said receiving mold so that the heat radiated from the molten glass vaporizes the liquid impregnated in the pores, and the pressure of this vaporized gas keeps the said molten glass supplied on the said receiving mold in the floating state so that the glass gob with a desired surface condition can be formed.

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[Claim 2]
The manufacturing method of the optical element forming material described in Claim 1 wherein supplying of a high pressure gas from the back surface of the said receiving mold characteristically forms the glass gob with the desired surface condition by receiving the molten glass on the said receiving mold while being backed-up by the said vaporized gas pressure.

[Claim 3]
The manufacturing method of the optical element forming material described in Claims 1 or 2 wherein the liquid supplied to the said receiving mold is characteristically water, liquid organic compounds, or aqueous solution of organic compounds.

[Claim 4]
The manufacturing method of the optical element forming material described in Claims 1 through 3 wherein the said receiving mold is constructed with ceramics such as carbon or alumina, or metallic porous material such as stainless steel having an air hole ratio of 10 to 40% and an average pore diameter of 5 to 50 μm.

[Claim 5]
The manufacturing method of the optical element forming material described in Claims 1 through 3 wherein the said liquid is characteristically applied to the receiving surface of the said receiving mold as a mist.

4. DETAILED EXPLANATION OF INVENTION

[Technical Field The Invention Belongs To]
The present invention relates to the glass gob supplied to the press forming (as the optical element forming material) in the optical element manufacturing method which obtains the optical element by press forming the glass material.

[Conventional Techniques]
Recently, the technique to obtain the formed optical element from the optical element forming material, a glass gob, by press forming the heat-softened glass gob by a mold is in progress. Accordingly, the development is active for the manufacturing method of the glass gob with a good appearance precision prior to the press forming step.

As the low cost manufacturing methods of these glass gobs, the manufacturing methods below are known. In other words, the molten glass poured down from the flow nozzle of the glass molten vessel is received on the receiving mold while spraying a gas from the receiving surface upwards so that the glass is maintained at the floating state above the receiving surface to form the molten glass gob. The glass gob obtained by this method has smooth free

surfaces for both the top and bottom surfaces and possesses a good appearance precision. Therefore, it can be directly supplied to the press forming without the post-processing, and the manufacturing cost is very low.

As the concrete example of the glass gob forming method by receiving the molten glass on the receiving mold with a gas spray hole, the method described in JP Kokoku H7-51446 is known. Also, the concrete examples of the glass gob formation method by receiving the molten glass on the receiving mold made of porous material while spraying a gas therefrom are known by JP Kokai H6-122526, JP Kokai H6-144845, and JP Kokai H6-206730.

[Problems Solved by Invention]

However, the said conventional methods have the following disadvantages. In other words, the gas flow spraying from the receiving mold solidifies the bottom of the molten glass gob bottom surface received by the receiving mold with an indent at the location corresponding to the gas spraying hole, or to the pores in the case of the porous receiving mold. Then the obtained glass gob has a bottom surface with a pit.

When such the glass gob with a pitted bottom surface is supplied to the press forming as the optical element forming material, nitrogen gas filled within the press forming instrument's chamber is taken into this pit section of the glass gob bottom surface during the press forming. As a result of the press forming under such the condition, the bottom of the formed optical element has a pitted section called "a gas residue". Therefore, the optical element does not have the desired precision, and becomes an out of specification product.

In order to prevent the generation of the pitted bottom in the glass gob, the amount of the spraying gas flow from the receiving mold gas spraying point or pores should be reduced. However, when the spraying gas flow is reduced, the weight of the molten glass makes the floating condition impossible and the receiving mold and the molten glass become in contact. As the result, the obtained glass gob has the surface transcripted from the receiving surface of the receiving mold. Particularly in the case of the porous receiving mold, the unevenness of the pores are transcripted as is, leading to a poor appearance precision and an unusable optical element forming material.

Particularly when the desired weight of the glass gob is small, 0.2 g to 5 g, the solidification of the molten glass is fast and the prevention of the pit at the bottom surface is technically difficult. For example, when the desired weight of the glass gob is at most 5 g, particularly at most 2 g, and when the gas flow spraying from the receiving mold floats the molten glass and forms the glass gob, the some degree of gas flow may cause the contact with the receiving mold and generate the bottom pit. In addition, the desired gas flow is practically difficult to achieve and impossible to control, therefore, the glass gob with a good appearance precision can not be obtained.

The inventors of the present invention studied the relationship between the glass gob pit and the gas flow for the floating in the case of the porous receiving mold, evaluated this from various angles, and reached to the following estimation. In other words, when the pressurized gas flow is provided to the bottom of the receiving mold and sprays to the top surface of the receiving mold in the conventional porous receiving mold, the rate distribution of the gas flow becomes faster at the center of the gas supplier tube 10 and slower at the surrounding as shown in Figure 6. This is attributed to the fluid resistance of the tube wall (viscous resistance of gas), and its influence spreads to the receiving mold 1 itself through the gas supply chamber 9 by the inertia of the gas flow. And the spraying gas flow distribution also becomes uneven with a larger distribution at the center.

This difference in the gas flow rates is particularly large right before the receiving of the molten glass on the receiving mold 1 and becomes smaller after the receiving of the molten glass. Yet, the difference in the spraying gas flow rate can be observed at the center and the surrounding sections. This is speculated as the cause of the glass gob pit.

The present invention was made based on the said background and its purpose is to offer the easy and sure manufacturing method of the glass gob which is suitable for the optical element forming material without a pit at the bottom surface.

And the second purpose is to offer the easy manufacturing method of glass gob which is suitable for the optical element forming material without a pit at the bottom surface and has a good mold releasing property at the post-processing step of optical element forming.

[Methods to Solve Problems]

For achieving the said purposes, the present invention is characterized by the manufacturing method of optical element forming material which forms the glass gob used as an optical element forming material by receiving the molten glass flown from a pouring nozzle to a porous receiving mold, wherein the liquid is supplied to the said receiving mold to impregnate the pores, then the said molten glass is supplied to the said receiving mold so that the heat radiated from the molten glass vaporizes the liquid impregnated in the pores, and the pressure of this vaporized gas keeps the said molten glass supplied on the said receiving mold in the floating state so that the glass gob with a desired surface condition can be formed.

In this case, the molten glass may be effectively supplied to the said receiving mold and formed into a glass gob with a desirable surface condition, while a high pressure gas supplied at the back surface of the said receiving mold is backing-up the said vaporized gas pressure.

Therefore, the liquid impregnated to the receiving mold is gradually vaporized below the molten glass supplied to the porous receiving mold, and the vaporized gas pressure generated from there and further the pressure of the additional high pressure gas backing-up the said vaporized gas keep the whole bottom surface of the molten glass in the floating state above the said receiving mold. At this time, the vaporization latent heat of the vaporized gas provides the cooling effect on the molten glass bottom section and it solidifies quickly. In addition, the pressure distribution of the vaporized gas is uniform at high density so that the floating state may be maintained with the level of the pressure which does not form a pit at the bottom of the glass gob.

When the temperature of the glass gob is lowered, the liquid does not vaporize any more, and when the floating condition can not be maintained, the bottom of the glass gob is sufficiently solidified by that time and the contact with the receiving surface of the receiving mold does not transcript the coarse surface condition of the receiving mold to the glass gob contact surface, maintaining the smooth surface. As a result, a high surface precision as the glass material being supplied to the consequent press forming is maintained, the generation of the out-of-specification optical element is reduced, and the yield is increased.

Further In this case, the liquid supplied to the said receiving mold is desirably water, liquid organic compounds, or aqueous solution of organic compounds. It is particularly important to surely generate the vaporized gas at the receiving surface at the reception of the molten glass. Therefore, the said liquid desirably possesses the melting point of at most 10 °C and the boiling point of at most 200 °C.

Further, the said receiving mold is desirably constructed with ceramics such as carbon or alumina or with metallic porous material such as stainless steel having an air hole ratio of 10 to 40% and the average pore diameter of 5 to 50 μm. In addition, it is effective to apply the said liquid to the said receiving mold as a mist for the uniform liquid vaporization at the receiving surface of the receiving mold.

[Execution of Invention]

(Execution 1)

Below, Execution 1 of the present invention is interpreted by referencing Figures 1 and 2. Here, in the manufacturing method of the optical element forming material wherein the glass gob 7 as the optical element forming material is formed by supplying the molten glass 6 poured from the glass melting vessel (platinum crucible) 4 through the flow nozzle 5 to the porous receiving mold 1, water manufactured by a pure water making device 2 is applied to the receiving mold 1 as a mist through the dispenser 3, the molten glass 6 is supplied to the receiving mold 1 while water is being impregnated in the pores, the heat radiated

from the molten glass 6 vaporizes water impregnated in the pores, and this vaporized gas pressure keeps the molten glass 6 supplied to the receiving mold 1 in the floating state and forms the glass gob 7 with a desired surface condition.

In this execution, water supply to the receiving mold 1, supply of the molten glass, and take-out of the glass gob after forming are carried out on the rotary table (not shown in the Figure) with 8 stations, as shown in Figure 2. In addition, pure water, the cheapest and safest liquid, is used as the liquid supplied to the receiving mold in this execution.

Generally supplied water comprises a trace amount of inorganics (calcium and so on) and the use of such the water as it is in the glass gob manufacturing of the present invention results in the precipitation of these contents on the receiving surface of the receiving mold, which adheres to the glass gob. When it precipitates within the pore, the pore is clogged and air flow is inconveniently impaired.

Therefore, when water is employed for the glass gob manufacturing of the present invention, the desirable water should contain at most 300 ppm of such the trace residual inorganics (for example, the said pure water has at most 10 ppm inorganics). Other liquids supplied to the receiving mold 1 are: liquid organic compounds such as halogenized hydrocarbon (perchloroethylene) and aqueous solution (for example 50 %) of organic compounds such as univalent alcohol and multivalent alcohol such as n-propyl alcohol. It is particularly important to surely generate the vaporized gas at the receiving surface at the reception of the molten glass. Therefore, the said liquid desirably possesses the melting point of at most 10 °C and the boiling point of at most 200 °C.

The glass gob 7 obtained by these procedures is maintained and cooled in the floating state above the receiving surface of the receiving mold 1. Therefore, its surface is a free surface with an extreme smoothness and a high surface precision necessary for the consequent press forming. In other words, the gas supplied from the bottom of the molten glass is the vaporized gas from the liquid (pure water in this execution), its vaporization latent heat rapidly solidifies the glass surface, and the uniform vaporization pressure with a high vapor density provides the sufficient floatation force at lower pressure. Therefore, the said smooth surface is obtained. In addition, the obtained glass gob 7 does not have a pit at its bottom since the high pressure by the excess gas flow in the conventional methods is not necessary.

Then, the steps concerning the glass manufacturing are interpreted. At first, a desired amount of water is applied to the circulating porous receiving mold 1 as a mist through the dispenser 3. Then, the receiving mold 1 which is impregnated with water is moved to the station position below the flow nozzle 5 and raised to right beneath the flow nozzle outlet 5. At this condition, the molten glass 6 is supplied to the receiving mold 1. When a tip of the molten glass 6 is

descended near the receiving surface of the receiving mold 1, the radiation heat from the molten glass 6 increases the temperature of the receiving surface of the receiving mold 1, which vigorously vaporizes the water impregnated to the receiving mold 1. This vaporized gas keeps the molten glass at a slightly floating state above the receiving surface of the receiving mold 1.

At this condition, the molten glass 6 is supplied to the receiving mold 1. When the weight of the molten glass on the receiving mold 1 reaches to the desired value, the receiving mold 1 is descended by a desired distance and the flow of the molten glass 6 is narrowed at the outlet of the flow nozzle 5. Maintaining at this condition for a while cuts off the molten glass 6 by itself.

As seen here, the vaporized gas released from the receiving mold 1 maintains the floating condition, proceeds the solidification, and forms the glass gob 7 with a smooth surface. The glass gob obtained by these procedures is sent to the next station along with the receiving mold 1. Even at this station, the glass gob 7 is still sufficiently hot and the vaporized gas is still released from the receiving mold 1, which keeps the glass gob 7 in the floating state.

While the receiving mold 1 is further sent to the next station, the temperature of the glass gob 7 is lowered, the spraying of the vaporized gas from the receiving mold 1 is reduced or gone, and the glass gob 7 is placed on the receiving surface of the receiving mold 1. However, by this time, the surface of the glass gob 7 is sufficiently solidified, therefore, the contact of the glass gob 7 with the receiving mold 1 does not leave the contact mark from the receiving mold 1 surface to the surface of the glass gob 7. The glass gob 7 obtained by these procedures are finally taken out by using a take-out autohand (not shown in the figure).

In this execution, the receiving mold 1 is desirably constructed with ceramics such as carbon or alumina or with metallic porous material such as stainless steel having an air hole ratio of 10 to 40%, more desirably at around 30% and the average pore diameter of 5 to 50 μm, more desirably of 15 μm. In addition, the temperature of the receiving mold 1 itself at the reception of the molten glass is desirable 80 to 300 °C, more preferably about 200 °C.

(Execution 2)

Then, Execution 2 of the present invention is concretely interpreted by referencing Figures 3 and 4. Here, the said Execution is further equipped with a pressurized gas supply method to back up the vaporized gas pressure. In other words, a high pressure gas is supplied to the back surface of the porous receiving mold 1 and this gas pushes the liquid impregnated in the pores through the pores of the receiving mold 1 and backs up the vaporized gas pressure at the receiving surface. It is important for the sure floatation of the glass gob when the glass gob weight per unit surface area is increased.

In concrete, the porous receiving mold 1 is held with the receiving mold holding block 8, and the back of the receiving surface of the receiving mold 1 is equipped with a gas supply chamber 9 surrounded by the receiving mold holding block 8. This gas supply chamber 9 is connected with a gas supply tube 10, as shown in Figure 3. As shown in Figure 4, the gas supply tube 10 may be constructed by being separated from the receiving mold holding block 8, so that it can move up and down for the ascending and descending of the receiving mold 1. The gas supplied from the gas supply tube 10 is supplied to the gas supply chamber 9 and then backs up the vaporized gas (water vapor) from the receiving surface of the porous receiving mold 1.

Here, water manufactured by a pure water making device 2 is added with the desired amount of organic compound and a desired amount of water is supplied to the receiving mold 1 as a mist through the dispenser 3. Then, the receiving mold is moved to the station position below the flow nozzle 5 and raised to right beneath the flow nozzle outlet 5. Then, the pressurized gas is supplied from the gas supply tube 10 and backs up the vaporization of the impregnated water. At this condition, the molten glass 6 is supplied to the receiving surface of the receiving mold 1. For the transfer of the receiving mold, the method such as belt conveyer 11, shown in Figure 4 is utilized.

When a tip of the molten glass 6 is descended near the receiving surface of the receiving mold 1, the radiation heat from the molten glass 6 increases the temperature of the receiving surface of the receiving mold 1, which vigorously vaporizes the water impregnated to the receiving mold 1. This vaporized gas and the pressurized gas backing up through the porous section keeps the molten glass at a slightly floating state above the receiving surface of the receiving mold 1.

At this condition, the molten glass 6 is supplied to the receiving mold 1. When the weight of the molten glass on the receiving mold 1 reaches to the desired value, the receiving mold 1 is descended by a desired distance and the flow of the molten glass 6 is narrowed at the outlet of the flow nozzle 5. Maintaining at this condition for a while cuts off the molten glass 6 by itself.

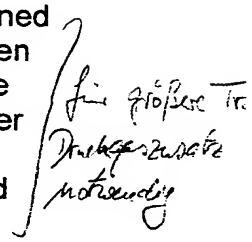
As seen here, the vaporized gas (water vapor) from the receiving mold 1 and the backing-up pressurized gas maintain the floating condition and forms the glass gob. Then, the receiving mold 1 is lowered and moved to the next station.

At the same time, the flow amount of the pressurized gas supplied from the back surface of the receiving mold 1 is gradually reduced. Even after the flow of the pressurized gas supplied to the receiving mold 1 reaches to 0, the glass gob 7 is sufficiently hot, and the vaporized gas (water vapor) is still coming from the surface of the receiving mold 1 and maintains the glass gob 7 in the floating state.

Then, in the process of being moved to the next cooling station, the temperature of the glass gob 7 is lowered, the spraying of the vaporized gas (water vapor) is reduced, and the glass gob 7 becomes in contact with the receiving surface of the receiving mold 1. However, at this time, the surface of the glass gob 7 is sufficiently cooled and solidified, therefore, the contact of the glass gob 7 with the receiving mold 1 does not leave the contact mark from the receiving mold 1 surface to the surface of the glass gob 7. The glass gob 7 obtained by these procedures are finally taken out by using a take-out autohand (not shown in the figure).

As a result, the obtained effect is the same as in the said Execution 1. Particularly in this execution, it is possible to maintain the sure floating function for the relatively heavier press mold objects (a usual object of this type is a convex lens with minimum weight of 0.2 g and maximum weight of 5.0 g).

Further, the detailed characteristics of this execution are as follows. The receiving mold 1 is releasing the vaporized gas of the supplied and impregnated liquid in the porous section of the receiving mold 1 at the reception of the molten glass on the receiving mold 1, which is backed up by the pressurized gas supplied from the back surface. Therefore, the molten glass is surely maintained in the floating condition above the receiving mold 1. As described before, when the vaporized gas for the flotation of the molten glass is alone by itself and the amount of gas generation is relatively small, there is no problems for the lighter weight of glass gob. However, when the weight becomes larger, the molten glass and the receiving surface of the receiving mold 1 become in contact and the contact scar of the receiving mold 1 may be resulted in the glass gob.



However, as seen in this execution, the adjustment of the flow amount of the pressurized gas supplied to the back surface of the receiving mold 1 backs up the vaporized gas pressure even when the glass gob is relatively heavy, which avoids the contact of the glass gob with the receiving mold 1.

After the molten glass is received on the receiving mold 1, the supply of the pressurized gas from the back surface of the receiving mold 1 may be continued or discontinued. There is no problem even when the supply of the pressurized gas is discontinued as long as the molten glass is maintained in the floating state above the receiving surface of the receiving mold 1 by the vaporized gas of the liquid impregnated to the receiving mold 1. However, when the weight of the desired glass gob is large, it is safe to continue the supply of the pressurized gas. And when the weight is small, the discontinue of the pressurized gas supply is economical.

Here, the molten glass is floating above the receiving surface of the receiving mold 1 and its surface is a free surface with an extreme smoothness. Further, the vaporization latent heat cools and solidifies the surface rapidly.

(Execution 3)

Execution 3 of the present invention utilizes a liquid organic compound or aqueous solution of organic compound, in place of water in the said Executions 1 and 2. Prior to the reception of the molten glass on the receiving mold 1, the porous section of the receiving mold 1 is supplied with a liquid organic compound or aqueous solution of organic compound so that the vaporized organic compound is released from the receiving surface, which maintains the molten glass in the floating condition. And at the same time, a part of the organic compound adheres on the glass surface.

In this Execution, the receiving mold 1 moves the square circulation path 11 along with the receiving mold holding block 8, as shown in Figure 5. At this process, the liquid is first sprayed on the receiving surface. Right after this procedure, the molten glass is supplied, and at the same time, the pressurized gas is applied for the back-up. Then the cooling process and the glass gob take-out are carried out at the later steps in the system. At each corner of the circulation path, a push rod 13 of the oil pressured or air pressured cylinder assembly (driving device) 12 changes the moving direction by 90 degrees to carry out the intermittent sending operation.

In addition, the receiving mold holding block is moved by a desired timing, so that the similar process as in Execution 2 except the intermittent driving of the cylinder assembly 12 forms the glass gob. Therefore, its process operations are omitted here.

A thin film of the organic compound is adhered on the surface of the glass gob 7 prepared by this process. In general, when a carbon type or hydrocarbon type thin film is adhered on the surface of the glass gob 7, the components in these organic compounds, particularly a carbon or hydrocarbon type thin film, plays a role of a mold releasing layer and weakens the adhesion force between the press mold and the optical element, at the later press forming process of the optical element. As a result, it improves the mold releasing property when the optical element is released from the press mold.

[Examples]

(Example 1)

Then, the concrete example of the present invention is shown for the Execution 1 of the present invention. In this example, the receiving mold 1 was formed with a porous carbon, of which air hole ratio is 30% and the average hole diameter was 15 μm. The receiving surface of the receiving mold 1 was finished into a concave spherical surface with a 15 mm radius. And the receiving mold 1 was held by the receiving mold holding block (not shown in the figure) with a cartridge heater inside. In this example, the said receiving mold holding block was always heated to 200 °C by the said cartridge heater.

The pure water manufacturing device 2 was an ion exchange type. By supplying the ordinal tap water to this pure water manufacturing device 2, various ions comprised in the tap water were eliminated. And the content of inorganics within this water was reduced to 10 ppm. Further, 0.2 cc of this water was applied to the receiving surface of each receiving mold 1 as a mist by the dispenser 3.

At this condition, the receiving mold 1 was moved to the position station below the molten glass flow pipe 5, ascended to the underneath of the flow pipe 5 outlet by 10 mm, and stopped. From the outlet of the flow pipe 5, molten glass 6 at 1000 °C was poured and dropped.

When the tip of this molten glass 6 came near the receiving surface of the receiving mold 1, the radiation heat of the molten glass increased the temperature of the receiving surface rapidly and the water impregnated to the receiving mold 1 vigorously vaporized. Since the receiving mold holding block (not shown in the figure) was maintained at 200 °C, the unsaturated water vapor was generated from the receiving mold right after the supply of water. However, when the tip of the molten glass 6 came closer, the generation of the vaporized gas (water vapor) from the receiving surface increased and demonstrated the sufficient power to float the molten glass.

When this condition was maintained, the molten glass was collected while being floated above the receiving surface of the receiving mold 1. In 3 seconds, the weight of the molten glass collected on the receiving mold 1 reached the desired weight, so then the receiving mold 1 was descended by 10 mm and the neck of the molten glass was created at the nozzle outlet. After maintaining this condition for 0.5 second, the glass flow was naturally cut from the nozzle outlet.

The half-solidified glass gob 7 obtained as above had a high temperature as a whole, however, its surface was rapidly cooled by the vaporization latent heat of the vaporized gas. In addition, the free surface was extremely smooth. The pressure of the vaporized gas from the receiving surface of the receiving mold 1 maintained the glass gob 7 in a slightly floated condition from the receiving surface. In this case, the high density of vaporized gas could float the glass gob 7 without a high moving pressure and without causing the pit at the center of the bottom surface.

As above, the receiving mold 1 was descended to the desired position while holding the glass gob 7 and moved to the next position station (cooling process). Five cooling stations are shown in this example and the glass gob 7 was naturally cooled here. Further in this example, the receiving mold 1 was moved every 5 seconds, therefore, the molten glass 6 was received on the receiving mold 1 and taken out by the take-out hand (not shown in the figure) 30 seconds later.

In the present example, a large amount of the vaporized gas (water vapor) was released from the receiving surface of the receiving mold 1 for about 10 seconds after the reception of the molten glass 6 on the receiving mold 1. Then, the released amount of the water vapor was reduced.

The glass gob 7 obtained by this procedure weighed 0.7 g having smooth free surfaces at both the top and the bottom, without a pit at the bottom. Therefore, it was a very suitable surface precision as the optical element forming glass material.

(Example 2)

Then, the concrete example of the present invention is shown for the Execution 2 of the present invention. In this example, water dissolved with a desired organic compound was impregnated to the porous section of the receiving mold 1, and the molten glass was received on the receiving surface of this receiving mold 1. At this time, the pressurized gas was supplied from the back surface of the receiving mold 1 and backed up the vapor pressure of the impregnated water.

In this example, the receiving mold 1 was formed with a porous carbon, of which air hole ratio was 30% and the average hole diameter was 15 μm. The receiving surface of the receiving mold 1 was finished into a concave spherical surface with a 15 mm radius. And the receiving mold 1 was held by the receiving mold holding block (not shown in the figure) with an inside cartridge heater. In this example, the said receiving mold holding block was always heated to 100 °C by the said cartridge heater.

The pure water manufacturing device 2 was an ion exchange type. By supplying the ordinal tap water to this pure water manufacturing device 2, various ions comprised in tap water were eliminated. And the content of inorganics within this water was reduced to 10 ppm. This water was added with 50 volume% of n-propyl alcohol. Further, 0.3 cc of this water was supplied to the receiving surface of each receiving mold 1 as a mist by the dispenser 3.

At this condition, the receiving mold 1 was moved to the position station below the molten glass flow pipe 5, ascended to underneath the flow pipe 5 outlet by 10 mm, and stopped. From the outlet of the flow pipe 5, molten glass 6 at 1000 °C was poured and dropped. At this time, pressurized nitrogen gas was supplied towards the porous section of the receiving mold 1 from its back surface at the flow rate of 10 liter/minute through the gas supply tube 10.

When the tip of this molten glass 6 came near the receiving surface of the receiving mold 1, the radiation heat of the molten glass increased the temperature of the receiving surface rapidly and the water impregnated to the receiving mold 1 vigorously vaporized. When this condition was maintained, the

molten glass was collected while being floated above the receiving surface of the receiving mold 1.

In 6 seconds, the weight of the molten glass collected on the receiving mold 1 reached the desired weight, so then the receiving mold 1 was descended lower by 10 mm and the neck of the molten glass was created at the nozzle outlet. After maintaining this condition for 0.5 second, the glass flow was naturally cut from the nozzle outlet. After obtaining the molten glass gob 7 by this procedure, the receiving mold 1 was descended to the desired position and moved to the next position station.

After moving the receiving mold 1 to the next station, the flow amount of the nitrogen gas supplied to the receiving mold 1 was gradually reduced and turned off in 3 seconds. However, even at this condition, the temperature of the glass gob 7 was sufficiently high, so that the vaporized gas (water vapor) was strongly released from the receiving surface of the receiving mold 1. Therefore, the glass gob 7 was maintained at the slightly floated condition above the receiving surface of the receiving mold 1 even after the discontinued supply of the nitrogen gas.

The glass gob 7 was naturally cooled at 5 cooling stations. In this example, the receiving mold 1 moved to the next station in 8 seconds. Therefore, the molten glass 6 was received on the receiving mold 1 and taken out by the take-out hand (not shown in the figure) 48 seconds later. Further in the present example, a large amount of the vaporized gas (water vapor) was released from the receiving surface of the receiving mold 1 for 22 seconds after the reception of the molten glass 6 on the receiving mold 1. Then, the released amount of the water vapor was reduced.

The glass gob 7 obtained by this procedure weighed 1.7 g having smooth free surfaces at both the top and the bottom, without a pit at the bottom. Therefore, it had a very suitable surface precision as the optical element forming glass material.

In addition, the surface of this glass gob 7 was adhered with a hydrocarbon film which is the vaporized n-propyl alcohol dissolved into water. Therefore, when this glass gob 7 is employed as the optical element forming material for the press molding to obtain the optical element, this hydrocarbon film functions as the mold releasing film as it is. Therefore it is possible to release the optical element from the mold at the relatively high temperature. In concrete, when this glass gob is press-formed at 600 °C and cooled, the glass gob of the present example can be released from the mold at 450 °C. When the ordinary glass is employed, the mold releasing is not possible until cooling to 400 °C. As shown here, the possible mold releasing at high temperature can shorten the forming cycle time by, for example, 1 minute.

In this example, n-propyl alcohol was exemplified as the organic compound being dissolved into water. However, the similar effect is available by other water soluble organic compounds and univalent alcohols and multivalent alcohols are particularly desirable.

(Example 3)

The concrete example of the execution of the present invention is discussed. In this example, the porous section is impregnated with water (pure water) and the pressurized nitrogen gas is supplied to the back surface of the receiving mold 1 to back up the vaporized gas (water vapor) released from the receiving surface of the receiving mold 1 through the porous section, only at the molten glass receiving process, as similarly in the Execution 2.

In this example, the receiving mold 1 was formed with a porous carbon, of which air hole ratio was 30% and the average hole diameter was 15 μm. The receiving surface of the receiving mold 1 was finished into a concave spherical surface with a 15 mm radius. And the receiving mold 1 was held by the receiving mold holding block 8.

In addition, the circulation path 11 was constructed to a square shape by the guide rail made with cast iron having a good vibrational property. Cylinder assembly 12 was a uni-axial robot controlled by NC. Its tip was attached with a push rod 13, which consequently pushed and moved the receiving mold holding block along the guide rail.

The pure water manufacturing device 2 was an ion exchange type. By supplying the ordinal tap water to this pure water manufacturing device 2, various ions comprised in tap water were eliminated. And the content of inorganics within this water was reduced to 10 ppm. Further, 0.3 cc of this water was uniformly supplied to the receiving surface of each receiving mold 1 as a mist by the dispenser 3.

The top of the gas supply tube 10 has a matched shape with the opening section of the gas supply chamber 9 in the receiving mold holding block 8, so then they can be connected. The sealing material (not shown in the figure) with a high temperature endurance at this section can maintain the air tightness when connected. In addition, the gas supply tube 10 can be move vertically by the NC controlled uni-axial robot (not shown in the figure) connected at the bottom.

After connecting the gas supply tube 10 and the receiving mold holding block 8, the pressurized nitrogen gas was supplied from the gas supply tube 10 to the back surface of the receiving mold 1 at the flow rate of 10 liter/minute. Through the porous section of the receiving mold 1, the impregnated water vapor was backed up during the vaporization.

Then the receiving mold 1 was moved to the position station below the molten glass flow pipe 5, ascended to underneath the flow pipe 5 outlet by 10 mm, and stopped. From the outlet of the said nozzle, molten glass 6 at 1000 °C was poured and dropped. When the tip of this molten glass 6 came near the receiving surface of the receiving mold 1, the radiation heat of the molten glass increased the temperature of the receiving surface rapidly and the water impregnated to the receiving mold 1 vigorously vaporized, to float the molten glass 6.

While this condition was maintained, the molten glass was collected while being floated above the receiving surface of the receiving mold 1. In 4.5 seconds, the weight of the molten glass collected on the receiving mold 1 reached the desired weight, so then the receiving mold 1 was descended by 10 mm and the neck of the molten glass was created at the nozzle outlet. After maintaining this condition for 0.5 second, the glass flow was naturally cut from the nozzle outlet. After receiving the molten glass gob 7, the receiving mold 1 was left on the guide rail along with the receiving mold holding block 8 and the gas supply tube 10 was further descended.

At this point, there was no supply of the pressurized nitrogen gas to the receiving mold 1, however, a sufficiently high temperature of the glass gob maintained the release of the vaporized gas (water vapor) from the receiving surface right underneath, and the receiving mold 1 maintained the glass gob 7 in a slightly floated condition above the receiving surface even after termination of the nitrogen gas back-up.

In the present example, after receiving the molten glass, the receiving mold 1 along with the receiving mold holding block 8 moved to the 10 cooling stations, residing for 6 seconds at each prior to the glass gob take-out. During this period the glass gob 7 was naturally cooled at these stations. And finally the molten glass 6 was taken out by the take-out hand (not shown in the figure) 60 seconds later. A large amount of the vaporized gas (water vapor) was released from the receiving surface of the receiving mold 1 for 14 seconds after the reception of the molten glass 6 on the receiving mold 1. Then, the released amount of the water vapor was reduced.

The glass gob 7 obtained by this procedure weighed 1.2 g having smooth free surfaces at both the top and the bottom, without a pit at the bottom. Therefore, it had a very suitable surface precision as the optical element forming glass material.

(Example 4)

The concrete example of the other execution of the present invention is discussed. In this example, the instrument shown in the said Execution 1 was employed. However, the storage tank (not shown in the figure) was placed in place of the pure water making device 2. A desired amount of the organic

compound stored here was supplied to the receiving surface of the receiving mold 1 through the dispenser 3.

In this example, the receiving mold 1 was formed with a porous carbon, of which air hole ratio was 30% and the average hole diameter was 15 μm. The receiving surface of the receiving mold 1 was finished into a concave spherical surface with a 15 mm radius. And the receiving mold 1 was held by the receiving mold holding block with an inside cartridge heater (not shown in the figure). In this example, the said receiving mold holding block was always heated to 200 °C by the said cartridge heater. The organic compounds stored in the storage tank was halogenized hydrocarbon, for example, perchloroethylene. The 0.2 cc amount of this compound was supplied to the receiving surface of each receiving mold 1 as a uniform mist by the dispenser 3.

Then the receiving mold 1 along with the receiving mold holding block was moved to the position station below the molten glass flow pipe 5, ascended to underneath the flow pipe outlet 5 by 10 mm, and stopped. From the outlet of the said nozzle outlet, molten glass 6 at 1000 °C was poured and dropped.

When the tip of this molten glass 6 came near the receiving surface of the receiving mold 1, the radiation heat of the molten glass increased the temperature of the receiving surface rapidly and perchloroethylene impregnated in the porous section vaporized and the vaporized gas was released vigorously. Since perchloroethylene vapor gas is inflammable, this vapor gas did not ignite when the molten glass was received on the receiving mold 1.

Since the receiving mold holding block is maintained at 200 °C in the present example, the perchloroethylene vapor was generated right after the supply of perchloroethylene to the receiving surface of the receiving mold 1. However, when the tip of the molten glass 6 came closer, the generation of the vaporized gas increased. While this condition was maintained, the molten glass was collected while being floated slightly above the receiving surface by the pressure of the generated vaporized gas.

In 3 seconds, the weight of the molten glass collected on the receiving mold 1 reached the desired weight, so then the receiving mold 1 was descended by 10 mm and the neck of the molten glass was created at the nozzle outlet. After maintaining this condition for 0.5 second, the glass flow was naturally cut from the nozzle outlet. A sufficiently high temperature of the obtained glass gob maintained the release of the vaporized gas from the receiving surface right underneath, and the receiving mold 1 kept the glass gob 7 in a slightly floated condition from the receiving surface.

After obtaining the molten glass gob 7, the receiving mold 1 was descended to the desired position and moved to the next station. The next

process is the five cooling stations, where the glass gob 7 is cooled naturally. In the present example, the receiving mold was moved to each station every 5 seconds. And finally the molten glass gob 7 was taken out by the take-out hand (not shown in the figure) 30 seconds after the reception of the molten glass 6. A large amount of the vaporized gas was released from the receiving surface of the receiving mold 1 for about 10 seconds after the reception of the molten glass 6 on the receiving mold 1. Then, the released amount was reduced.

The glass gob 7 obtained by this procedure weighed 0.7 g having smooth free surfaces at both the top and the bottom, without a pit the bottom. Therefore, it had a very suitable surface precision as the optical element forming glass material. In addition, the surface of this glass gob 7 was adhered with a hydrocarbon film which is the vaporized perchloroethylene. Therefore, when this glass gob 7 was employed as the optical element forming material for the press molding to obtain the optical element, this hydrocarbon film played a role of the mold releasing film. Therefore it was possible to release the optical element from the mold at the relatively high temperature.

In concrete, when this glass gob was press-formed at 600 °C and cooled, the glass gob of the present example was released from the mold at 450 °C. When the ordinary glass was employed, the mold releasing was not possible until being cooled to 400 °C. As shown here, the possible mold releasing at high temperature can shorten the forming cycle time by 1 minute.

In this example, perchloroethylene was exemplified as the organic compound being impregnated in the receiving mold 1. However, the similar effect is available by other organic compounds. Those hardly igniting their vaporized gas are particularly desirable and in concrete, halogenized hydrocarbons are desirable.

[Effects of Invention]

As described above, the present invention floats the molten glass by the generated vaporized gas when receiving the molten glass on the receiving mold. In addition, its high density confirms the sufficient floating force even with a low moving pressure, in contrast to a gas. Therefore, the obtained glass gob possesses free surfaces with an extreme smoothness. In addition, the lack of the pit at the bottom makes it extremely suitable as the optical element forming material.

Further, the employment of the gas for backing up the vaporized gas results in the glass gob suitable for the optical element forming material which has smooth surfaces and no pit at the bottom, even when the glass gob is heavy.

Finally, the selection of the liquid supplied to the receiving surface of the receiving mold results in the glass gob suitable for the optical element forming material having an improved mold releasing performance.

5. SIMPLE EXPLANATION OF FIGURES

Figure 1 – A side view diagram to interpret the instrument constitution for Execution 1 of the present invention.

Figure 2 – The similar flat diagram to explain the devise constitution.

Figure 3 – A side view diagram of the important section in Execution 2 of the present invention.

Figure 4 – A side view diagram of the example which utilized the gas supply tube also as the receiving mold holding block ascent measure.

Figure 5 – A flat view diagram to interpret the instrument constitution for Execution 3 of the present invention.

Figure 6 – A vertical cross-sectional side view diagram of the receiving mold to interpret the function of the conventional instrument.

[Interpretation of Codes]

1 – porous receiving mold,
2 – pure water making device
3 – dispenser,
4 – melting crucible
5 – flow pipe,
6 – molten glass,
7 – glass gob,
8 – receiving mold holding block,
9 – gas supply chamber
10 – gas supply tube
11 – transfer method.

Figure 1

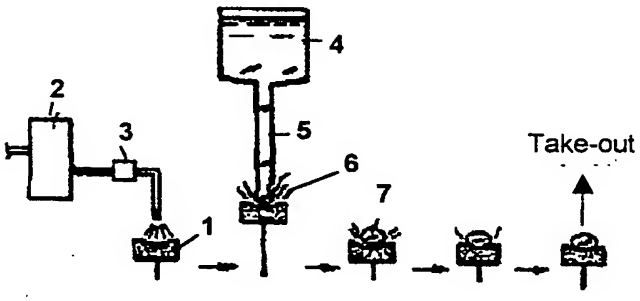


Figure 2

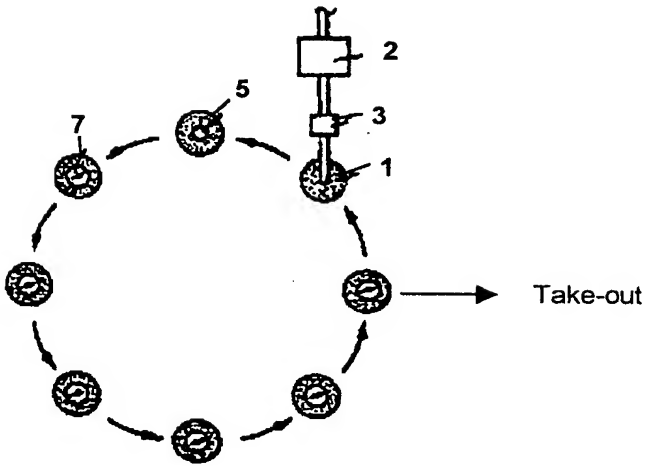


Figure 3

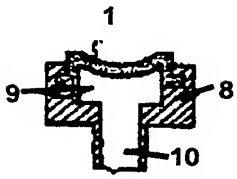


Figure 4

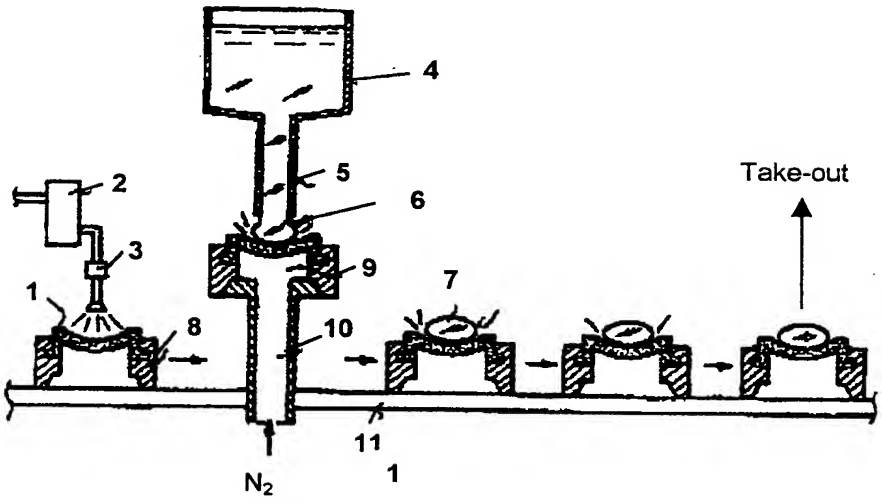


Figure 5

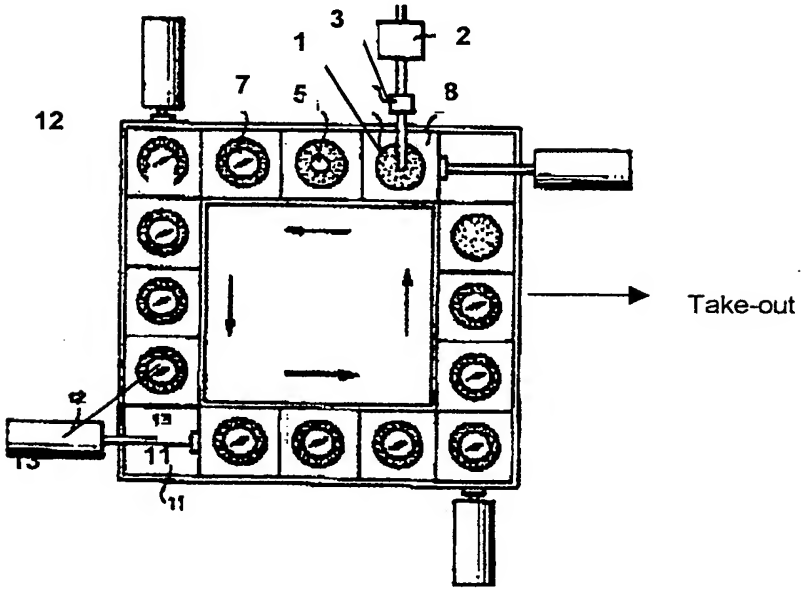


Figure 6